

Notice No.7

Rules and Regulations for the Classification of Special Service Craft July 2016

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately. Please note that paragraphs, Tables and Figures are not shown in their entirety.

Issue date: June 2017

Amendments to	Effective date	Mandatory Instrument
Part 9, Chapter 2, Section 1	1 July 2017	NA
Part 10, Chapter 1, Sections 1, 2, 12 & 13	1 July 2017	NA
Part 10, Chapter 1, Section 1	Corrigendum	NA
Part 14, Chapter 1, Sections 1 & 6	1 July 2017	X
Part 14, Chapter 1, Section 6	Corrigendum	NA
Part 15, Chapter 3, Section 2	1 July 2017	X
Part 16, Chapter 1, Sections 1, 2 & 7	1 July 2017	NA
Part 16, Chapter 2, Sections 1, 5, 6 & 21	1 July 2017	X

Part 9, Chapter 2

Surveys During Construction, Installation and Sea Trials

■ Section 1

General requirements

1.3 Alternative ~~system of survey~~ approach for product assurance

1.3.1 LR will be prepared to give consideration to the adoption of an approach for product assurance, utilising regular and systematic audits of ~~the approved manufacturing and quality control processes and procedures~~ an organisation's arrangements for assuring product quality as an alternative to the direct survey of individual items.

1.3.2 Alternative approaches for product assurance are to be approved by LR. In order to obtain approval, the requirements of *Pt 5, Ch 1, 6 Quality Assurance Scheme for Machinery* or the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2, Ch 1, 2.4 Materials Quality Scheme* are to be complied with. Proposals for equivalent approaches are to be submitted for consideration.

Part 10, Chapter 1

Reciprocating Internal Combustion Engines

Section 1

General requirements

1.2 Approval process

1.2.1 All engines intended for installation on an LR Class ship are to be Type Approved by LR (see Lloyd's Register Type Approval System Procedure TA14 for details of the LR Type Approval process); LR Type Approval is explained in *Pt 1, Ch 2, 6.1 LR Type Approval – Marine Applications*. LR Type Approval of an engine type will be granted following:

- (a) ~~satisfactory design appraisal (see Pt 10, Ch 1, 1.3 Submission requirements for submission requirements).~~
- (b) ~~approval of type testing programme and satisfactory type testing (see Pt 10, Ch 1, 14.1 Engines).~~
- (c) ~~acceptance of the place of manufacture (meet LR requirements for conformity of production).~~

1.2.5 An LR Engine Certificate is issued upon satisfactory completion of engine assembly, with associated component testing (see *Pt 10, Ch 1, 2 Materials and components*) and factory acceptance testing (see *Pt 10, Ch 1, 11 Factory Acceptance Test and Shipboard Trials of Engines*) or, issued in accordance with the alternative approach for product assurance approved by LR, see *Pt 10, Ch 1, 1.2 Approval process 1.2.7 Pt 9, Ch 2, 1.3 Alternative approach for product assurance*.

1.2.7 ~~The engine manufacturer is to apply an approach for product assurance that is suitable for, and includes, the engine types to be certified, see Pt 9, Ch 2, 1.3 Alternative approach for product assurance and Pt 1, Ch 2, 6.3 Quality Control System. Materials and components are to be manufactured in accordance with this approach and the Rules for the Manufacture, Testing and Certification of Materials, July 2016, herein after as applicable.~~

1.3 Submission requirements

Table 1.1.1 Plans and particulars to be submitted

Document	For information	For appraisal
	(x indicates reasons for submission)	
Construction of accumulators (common rail) for electronically controlled engine		X
Construction of common accumulators (common rail) for electronically controlled engine		X

Section 2

Materials and Components

2.2 ~~Test and inspections~~ Testing and inspection

2.2.1 Except where *Pt 10, Ch 1, 2.2 Test and inspections 2.2.2 Pt 10, Ch 1, 2.2 Testing and inspections 2.2.3* applies, materials and components for engines are to be manufactured and tested in accordance with the relevant requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No.1 & 2 and Table 1.2.1 Summary of testing and associated documentation and testing for engine components*.

2.2.2 All testing and inspection in *Table 1.2.1 Summary of testing and associated documentation for engine components* is to be documented by manufacturer's certificate, see *Pt 10, Ch 1, Test and inspection 2.2.8*, except where LR engagement is explicitly required.

~~2.2.2~~ 2.2.3 Where an alternative approach for product assurance has been approved by LR (see *Pt 9, Ch 2, 1.3 Alternative approach for product assurance*);

- (a) Testing and inspection identified as requiring LR engagement in *Table 1.2.1 Summary of testing and associated documentation for engine components* may be carried out and documented by the manufacturer in accordance with the approved alternative approach for product assurance.
- ~~(a)~~ (b) Any agreed variation to the requirements given in *Table 1.2.1 Summary of testing and associated documentation and testing for engine components* is to be included within the alternative approach for product assurance documentation scheme certification schedule.
- ~~(b)~~ The types of certification as given by (a) and (b) in *Table 1.2.1 Summary of documentation and testing for engine components* may be accepted; otherwise, testing and inspection is to be documented by an LR Certificate. Where (a) or (b) is not specified in *Table 1.2.1 Summary of documentation and testing for engine components*, the certification requirements as given by the other relevant parts of the Rules apply, see Notes to *Table 1.2.1 Summary of documentation and testing for engine components*.

2.2.4 All material for components listed in *Table 1.2.1 Summary of testing and associated documentation for engine components* is to be from an LR approved manufacturer, and manufactured within the scope of approval of that manufacturer, except where explicitly stated otherwise in other Parts and Chapters of the Rules.

Existing paragraphs 2.2.3 to 2.2.6 have been renumbered 2.2.5 to 2.2.8.

Table 1.2.1 Summary of testing and associated documentation and testing for engine components

Part	Material properties see Note 2	Non-destructive examination	Hydraulic testing see Pt 10, Ch 1, 2.3 Hydraulic tests 2.3.1 Note 4	Dimensional inspection see Note 3	Visual inspection see Note 5	Applicable to engines	LR Component Certification see Note 4
Welded bedplate	C + LR(M) (b)	UT + CD (b)	-	-	LR(V) fit-up + post-welding	All	×
Bearing transverse girders (cast steel)	C + LR(M) (b)	UT + LR(CD) (b)	-	-	LR(V)	All	×
Welded frame box see Note 5	C + LR(M) (b)	UT + CD (b)	-	-	LR(V) fit-up + post-welding	All	×
Cylinder block (cast iron)	LR(M) (b)	-	LR(P) (b) see Note 67	-	-	Crosshead	-
Welded cylinder frames see Note 56	C + LR(M) (b)	UT + CD (b)	-	-	LR(V) fit-up + post-welding	Crosshead	×
Engine block (cast iron)	LR(M) (b)	-	LR(P) (b) see Note 67	-	-	>400kW/cylinder	-
Cylinder liner	C + LR(M) (b)	-	LR(P) (b) see Note 67	-	-	B>300mm	-
Cylinder head (cast iron) see Note 7	LR(M) (b)	UT + CD (b)	LR(P) (b)	-	-	B>300mm see Note 8	-
Cylinder head (cast steel)	C + LR(M) (b)	UT + LR(CD) (b)	LR(P) (b)	-	LR(V)	B>300mm see Note 8	×
Cylinder head (forged)	C + LR(M) (b)	UT + LR(CD) (b)	LR(P) (b)	-	LR(V)	B>300mm see Note 8	×
Piston crown (cast steel) see Note 9	C + LR(M) (b)	UT + LR(CD) (b)	-	-	LR(V)	B>400mm see Note 8	×
Piston crown (forged)	C + LR(M) (b)	UT + LR(CD) (b)	-	-	LR(V)	B>400mm see Note 8	×
Crankshaft (one piece)	LR(C + M) (a)	UT + LR(CD) (b)	-	D (b)	LR(V) (Random, of fillets and oil bores)	All	×
Semi-built crankshaft (Crankthrow, forged main journal and journals with flange)	LR(C + M) (a)	UT + LR(CD) (b)	-	D (b)	LR(V) (Random, of fillets and shrink fittings)	All	×
Exhaust gas valve cage	LR(M) (b)	-	LR(P) (b)	-	-	Crosshead	-
Piston rod	LR(C + M) (a)	UT + CD (b) (CD again after final machining (grinding))	-	-	LR(V) (Random)	B>400mm	×
Crosshead pin	LR(C + M) (a)	UT + CD (b) (CD again after final machining (grinding and polishing))	-	-	LR(V) (Random)	Crosshead	×
Connecting rod with cap	LR(C + M) (a)	UT + LR(CD) (b)	-	D (b)	LR(V) (Random, of	All	×

					all surfaces in particular those shot peened)		
Crankshaft coupling bolts	LR(C + M) (a)	UT + CD (b)	-	D (b)	LR(V) (Random, of interference fit)	All	X
Bolts and studs for cylinder heads, crossheads, main bearings and connecting rods see Note 10	C + LR(M) (b)	UT + CD (b)	-	TR [thread making]	-	B>300mm	-
Tie rod see Note 11	C + LR(M) (b)	UT + CD (b)	-	TR [thread making]	LR(V) (Random)	Crosshead	X
High pressure fuel injection system – valve and pump body (pressure side) see Notes 12, 13, 14 and 15	LR(C + M)	-	LR(Lesser of 1,5pP or p+300 bar MPa)	-	-	All	-
High pressure fuel injection pipes including common rail see Notes 12, 14 and 15	LR(C + M)	-	LR(Lesser of 1,5pP or p+300 bar MPa)	-	-	All	-
High pressure common servo oil system see Notes 14 and 15	LR(C + M)	-	LR(Lesser of 1,5pP or p+300 bar MPa)	-	-	All	-
Coolers, both sides see Notes 14 and 16	LR(C + M)	-	LR(P)	-	-	B>300mm	-
Accumulator of common rail fuel or servo oil system see Note 14	LR(C + M)	-	LR(Lesser of P or p+30 MPa)	-	-	Accumulators with a capacity >0,5l	-
Piping, pumps, actuators, etc., for hydraulic drive of valves, if applicable see Note 14	LR(C + M)	-	LR(P)	-	-	>800kW/cylinder	-
Engine-driven pumps (oil, water, fuel, bilge) see Note 14	LR(C + M)	-	LR(P)	-	-	>800kW/cylinder	-
Bearings for (main, crosshead, and crankpin) see Note 17	TR [C]	TR [UT]	-	D (b)	- LR(V)	>800kW/cylinder	-
Turbocharger, shaft and rotor see Note 18	C + M	UT + CD	-	D	-	All	X see Note 19
Turbocharger casing see Note 18	C + M (b)	-	Greater of 4,0 bar or 1,5p (b)	-	-	All	X see Note 19
Air compressor including cylinders, liners, covers, intercoolers and after coolers see Notes 16 and 20	C + M (a)	-	Air side: P Water side: Greater of 4,0 bar or 1,5p(a)	-	-	-	X

SYMBOLS:

B = Bore dimension, refers to engine cylinder bores

C = Chemical composition analysis

M = Mechanical property analysis

(a)/(b) = see Note 1

UT = Ultrasonic testing (see Note 1)

CD = Crack detection by MPI or DPT (see Note 218)

D = Dimensional inspection, including surface condition

p = Maximum working pressure of item concerned

P = Pressure test at 1,5p

V = Visual examination of accessible surfaces (conducted by Surveyor)

- = No explicit requirement for documentation or testing

LR () = Test/inspection to be certified by LR except where Pt 10, Ch 1, 2.2 Testing and inspections 2.2.3 applies.

TR[] = Test report required for process in brackets (see Pt 10, Ch 1, 2.2 Test and inspections 2.2.5 Pt 10, Ch 1, 2.2 Testing and inspections 2.2.7)

X = LR Component Certificate required once the finished component is in the state required for fitting into an engine

Note 1. Alternative test certification, see Pt 10, Ch 1, 2.2 Test and inspections 2.2.2:

- a. stands for a product certificate issued under an alternative system for product assurance approved by LR (equivalent to an LR Certificate), e.g. a QAM Product Certificate, see Rules and Regulations for the Classification of Ships, July 2016 Pt 5, Ch 1, 6.3 QAM Scheme Arrangements 6.3.3, or a Manufacturer's Certificate issued under QAM (see Rules and Regulations for the Classification of Ships, July 2016 Pt 5, Ch 1, 6.4 Acceptance of purchased materials, components and equipment 6.4.2) or MQS (see Rules for the Manufacture, Testing and Certification of Materials, July 2016 Ch 1, 3.1 General 3.1.3(d)).
- b. stands for a Manufacturer's certificate (see Pt 10, Ch 1, 2.2 Test and inspections 2.2.6)

Note 1. Ultrasonic testing is not required for components manufactured from cast iron.

Note 2. Material properties include chemical composition and mechanical properties, as identified in the table above, and also Where mechanical testing is required this is to include testing of surface treatment, such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force) as applicable. Mechanical tests are to be conducted after the final heat treatment has been applied.

Note 3. Dimensional inspection is to include assessment of surface condition.

Note 4. An LR Component Certificate will be issued for finished components once they are in the state required in order to assemble them into an In cases where an alternative approach for product assurance is in operation, satisfactory review of all manufacturer certified testing (batch or individual) is required before an LR Component Certificate can be issued.

Note 4. Hydraulic testing is applied on the water/oil side of the component. The full lengths of cooling spaces are to be tested, where applicable. Where design or testing features may require modification of these test requirements, special consideration may be given.

Note 5. Certificates issued for visual inspection, either following satisfactory survey or under an approved LR Quality Scheme, are to be considered as component certificates.

Note 56. Where welding is carried out, welding and welder qualifications are to be carried out in accordance with the Rules for the Manufacture, Testing and Certification of Materials, July 2016, Ch 12 Welding Qualifications.

Note 67. Hydraulic testing is also required for those parts filled with cooling water and having the function of containing the water which is in contact with the cylinder or cylinder liner.

Note 7. For the purposes of these Rules, the term 'cylinder head' also refers to 'cylinder cover'.

Note 8. Ultrasonic examination is required for all cylinder heads and piston crowns. This may be waived for components for engines below the size specified in the column headed 'Applicable to Engines' where alternative means are provided to confirm that the component is free from internal defects. Components manufactured from spheroidal or nodular graphite iron castings may not be suitable for ultrasonic NDE, depending upon the grain size and geometry. An alternative NDE procedure is to be agreed with LR, see Rules for the Manufacture, Testing and Certification of Materials, July 2016 Ch 7, 1.8 Visual and non-destructive examination 1.8.4.

Note 218. Magnetic particle testing is to be carried out on ferro-magnetic materials, penetrant testing is only to be carried out on non-ferritic materials. Visual examination alone is not considered sufficient. Magnetic particle and dye penetrant testing are to be carried out when the forgings are in the finished machined condition.

Note 9. Where the piston rod seals the piston crown cooling space, it is to be tested after assembly.

Note 10. See also Rules for the Manufacture, Testing and Certification of Materials, July 2016, Ch 5, 3.5 Non-destructive examination 3.5.1 See also Rules for the Manufacture, Testing and Certification of Materials, July 2016, Ch 5, 3.5 Non-destructive examination 3.5.1 for detailed non-destructive examination requirements for other bolts and studs.

Note 11. Magnetic particle testing of tie rods may be confined to the threaded portions and the adjacent material over a length equal to that of the thread.

Note 12. Where components are subjected to an autofrettage process accepted by LR (see Pt 10, Ch 1, 2.5 2.4 Autofrettage), the component pressure test may be omitted. The assembled system containing such components is to be shown, where practicable, to be pressure-tight as required for hydraulic systems.

Note 13. Pumps used in jerk or timed pump systems only need to have the assembled high pressure containing components hydraulically tested.

Note 14. See also Pt 10, Ch 1, 8 Piping. Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature. Requirements given in this Table apply except where alternative requirements are explicitly given

in Pt 15, Ch 1 Piping Design Requirements and Pt 15, Ch 3 Machinery Piping Systems.

Note 15. Where an alternative approach for product assurance approved by LR is in operation, components for engines with a bore of less than 300mm or less may be supplied with test reports (as described in *Pt 10, Ch 1, 2.2 Test and inspections 2.2.5 Pt 10, Ch 1, 2.2 Testing and inspections 2.2.7*) instead of test certificates for pressure testing and materials tests, see *Pt 10, Ch 1, 2.2 Test and inspections 2.2.2 Pt 10, Ch 1, 2.2 Testing and inspections 2.2.3*.

Note 16. Material and component certification for accumulators or coolers which are classed as pressure vessels are dependent on the operating pressure and temperature, see *Rules and Regulations for the Classification of Ships, July 2016 Pt 5, Ch 11, 1.5 Classification of fusion welded pressure vessels and Rules and Regulations for the Classification of Ships, July 2016 Pt 5, Ch 11, 1.7 Materials. Charge air coolers are only to be tested on the water side.*

Note 17. Ultrasonic testing is required to prove full adhesion between basic material and bearing metal.

Note 18. Category A turbocharger test results are only required if specifically requested. Category B turbocharger testing may be documented by manufacturer's certificate where an approach for product assurance approved by LR is operated, Category C turbocharger materials tests and pressure tests are to be conducted under survey and LR certificates issued. See *Pt 10, Ch 1, 12.1 General 12.1.2*.

Note 19. An LR Component Certificate is only required for Category C turbochargers, see *Pt 10, Ch 1, 12.1 General 12.1.2*.

Note 20. Manufacturer's certification for materials and pressure testing will be accepted for air compressors with a calculated crankpin diameter of less than 50mm.

2.3 Hydraulic tests

2.3.1 Hydraulic testing is to be carried out on engine components as identified in *Table 1.2.1 Summary of documentation and testing for engine components*. Hydraulic testing is to be carried out on components for all engine sizes; this may be waived for components for engines below the size specified in the column headed 'Applicable to Engines' where alternative means are provided to confirm that the component integrity is satisfactory.

2.3.2 Hydraulic testing is applied on the water/oil side of the component. The full lengths of cooling spaces are to be tested, where applicable. Where design or testing features may require modification of these test requirements, special consideration may be given.

Sub-Sections 2.4 and 2.5 have been renumbered 2.3 and 2.4.

■ Section 12 Turbochargers

12.1 General

12.1.1 Turbochargers are to be approved, either separately or as a part of an engine. The requirements are written for exhaust gas driven turbochargers, but apply in principle also for engine driven chargers.

12.2 Works testing and inspection

12.2.1 LR Surveyors are to be provided with free access to the manufacturer's works to inspect at random the quality control measures and to witness the tests required by *Pt 10, Ch 1, 12.2 Works testing and inspection 12.2.2 to Pt 10, Ch 1, 12.2 Works testing and inspection 12.2.4* as deemed necessary, and to have free access to all control records and subcontractor's certificates.

12.2.2 Each individual unit is to be tested in accordance with *Pt 10, Ch 1, 12.2 Works testing and inspection 12.2.4 12.2.3 to Pt 10, Ch 1, 12.2 Works testing and inspection 12.2.7 12.2.8*. For category C turbochargers these tests are to be conducted under survey unless an alternative approach for product assurance has been approved by LR. For category B turbochargers the testing is to be documented by manufacturer's certificate. For category A turbochargers, test results, documented by manufacturer's certificate, are only required if specifically requested by LR.

12.2.4 Material tests (chemical composition and mechanical properties) and dimensional inspection, of the rotating parts and casing are to confirm compliance with the approved design and material specifications (see *Pt 10, Ch 1, 1.3 Submission requirements 1.3.4 1.3.5*). Testing and certification and inspection of turbocharger casings and rotor shafts are to comply with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2* as applicable.

12.2.6 12.2.5 Pressure tests are to be carried out in accordance with *Table 1.2.1 Summary of documentation and testing for engine components*. Special consideration will be given where design or testing features may require modification of the test requirements. Cooling spaces are to be hydraulically tested to 0,4 MPa gauge or 1,5 times maximum working pressure, whichever is higher.

12.2.6 Rotating parts are to be subjected to ultrasonic testing and surface crack detection (magnetic particle testing is to be carried out on ferro-magnetic materials, penetrant testing is only to be carried out on non-ferritic materials). Ultrasonic testing is not required for components manufactured from cast iron.

~~42.2.5~~ **12.2.7** All rotors are to be dynamically balanced on final assembly.

~~42.2.7~~ **12.2.8** All compressor wheels are to be overspeed tested for three minutes at either 20 per cent above the alarm level speed at room temperature, or 10 per cent above alarm level speed at 45°C inlet temperature when tested in the actual housing with the corresponding pressure ratio. The overspeed test may be waived for forged wheels that are individually controlled by an approved non-destructive method. This test will not be waived for wheels of the unit to be type tested.

12.3 Certification

~~42.3.1~~ The manufacturer is to adhere to a quality system designed to ensure that the designer's specifications are met, and that manufacturing is in accordance with the approved drawings.

~~42.3.2~~ **12.3.1** Turbochargers are to be delivered with:

- (a) Category B turbochargers: ~~a~~ A manufacturer's certificate, which states the applicable type approval, including production assessment.
- (b) Category C turbochargers: ~~a~~ An LR certificate or LR Quality Scheme Product Certificate as applicable, which states the applicable ~~type approval and, if applicable the LR Quality Scheme when applicable~~ and LR Quality Scheme reference, if applicable.

~~42.3.3~~ **12.3.2** Where the manufacturer operates a quality control system agreed with an alternative approach for product assurance approved by LR the periodic audits will include specific focus on:

- (a) Chemical composition of material for the rotating parts.
- (b) Mechanical properties of the material of a representative specimen for the rotating parts and the casing.
- (c) UT and crack detection of rotating parts.
- (d) Dimensional inspection of rotating parts.
- (e) Rotor dynamic balancing.
- (f) Hydraulic testing of cooling spaces ~~in accordance with Table 1.2.1 Summary of documentation and testing for engine components. as per Pt 10, Ch 1, 12.2 Works testing and inspection 12.2.5.~~
- (g) Overspeed test of all compressor disks as per ~~Pt 10, Ch 1, 12.2 Works testing and inspection 42.2.7~~ **12.2.8**.

~~42.3.4~~ **12.3.3** The above certification and test requirements also apply to replacement rotating parts and casing.

■ Section 13 Air compressors

13.5 Testing

~~43.5.1~~ Air compressors components are to be tested as indicated in ~~Table 1.2.1 Summary of documentation and testing for engine components.~~

13.5.1 Cast Iron crankshafts for air compressors are to be manufactured and tested in accordance with the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2, Ch 7, 5 Iron castings for crankshafts*. Crankshafts for air compressors manufactured from other materials are to be tested in accordance with the applicable requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2*. Ultrasonic testing is not required for components manufactured from cast iron.

13.5.2 Cylinders, covers and liners of air compressors are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.

13.5.3 The compressed air chambers of the intercoolers and aftercoolers of air compressors are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.

13.5.4 Manufacturer's certification for materials and pressure testing will be accepted for air compressors with a calculated crankpin diameter of less than 50 mm.

13.5.5 After construction all compressors are to be subjected to a running test to the satisfaction of the attending Surveyor.

Part 14, Chapter 1

Steering Systems

■ Section 1

General requirements

1.1 Application

1.1.2 The requirements given in *Pt 5, Ch 19 Steering Systems* of the *Rules and Regulations for the Classification of Ships* are to be applied to vessels required to comply with SOLAS.

Existing paragraphs 1.1.2 to 1.1.4 have been renumbered 1.1.3 to 1.1.5.

■ Section 6

Control, monitoring and electrical equipment

6.1 Control

6.1.1 In addition to this section, the control and electrical installation of the steering control system is to comply with *Pt 16 Control and Electrical Engineering*.

Existing paragraphs 6.1.1 to 6.1.7 have been renumbered 6.1.2 to 6.1.8.

6.1.7 6.1.8 Arrangements for failure detection are to be provided with self-monitoring capabilities. In the event of failure being detected, an audible and individual visual alarm is to be initiated on the navigating bridge. See *Pt 14, Ch 1, 6.2 Monitoring and alarms*. Where the system failure alarms for hydraulic lock, see *Table 1.6.1 Alarms*, are provided, appropriate instructions are to be placed on the navigating bridge to shut down the system at fault.

6.1.9 In the event of detecting a control system failure, which is likely to cause uncontrolled rudder movements, see *Table 1.6.1 Alarms*, the rudder is to retain its position at the time of failure. Alternatively, consideration will be given to the rudder moving to and retaining a position which is necessary for safe navigation of the craft or to return to the mid-ship position where technical justification is submitted and is found to be satisfactory.

6.2 Monitoring and alarms

Table 1.6.1 Alarms

Item	Alarm	Note
Angular position of the Steering Mechanism	-	Indication, see <i>Pt 14, Ch 1, 6.1 Control</i> 6.1.6
	Failure	See <i>Pt 14, Ch 1, 6.2 Monitoring and alarms</i> 6.2.4
Earthing on AC and DC circuits	Fault	If galvanically isolated from the ship's network
Data communication	Error	Where the data deviates from expected value, sequence or timing
Steering power units, power	Failure	-
Steering motors	Overload Single phase	For alarm and running indication locations, see <i>Pt 14, Ch 1, 6.3 Electrical equipment</i> 6.3.3 and <i>Pt 14, Ch 1, 6.3 Electrical equipment</i> 6.3.4
Control system	Failure	See <i>Pt 14, Ch 1, 6.2 Monitoring and alarms</i> 6.2.4
Control system power	Failure	-
Steering gear hydraulic oil tank level	Low	Each reservoir to be monitored. For Alarm locations, see <i>Pt 14, Ch 1, 6.3 Electrical equipment</i> 6.3.5
Auto pilot	Failure	Running indication
Hydraulic oil temperature	High	Where oil cooler is fitted
Hydraulic lock	Fault	Where more than one system (either power or control) can be operated simultaneously each system is to be monitored see Note
Hydraulic oil filter differential pressure	High	When oil filters are fitted
Note: This alarm is to identify the system at fault and to be activated when (for example): <ul style="list-style-type: none"> position of the variable displacement pump control system does not correspond with given order; or incorrect position of 3-way full flow valve or similar in constant delivery pump system is detected. 		

Part 15, Chapter 3

Machinery Piping Systems

■ Section 2

General requirements

2.2 Fuel oil sampling

2.2.1 Sampling points are to be provided at locations within the fuel oil system. The design and location of sampling points is to enable samples of fuel oil to be taken easily and in a safe manner.

2.2.2 The position of a sampling point is to be such that the sample of the fuel oil is representative of the fuel oil quality at that location within the system, e.g. by ensuring steady state flow past the sampling point.

Note Samples taken from sounding pipes and tank drain cocks are not considered to be representative of the tank's contents.

2.2.3 Sampling points are to be located so as to reduce the possibility of fuel oil coming into contact with any heated surface or electrical equipment under reasonably foreseeable operating conditions and therefore shall be positioned as far away as possible from such surfaces or equipment. Where contact is still likely, positions are to be shielded from any heated surface or electrical equipment. The shielding shall be sturdy enough to endure leaks, splashes or spray under design pressure of the fuel oil supply line.

2.2.4 A sampling point or points shall be provided:

- (a) Taking into account different fuel oil grades being used for the fuel oil combustion machinery item;
- (b) Downstream of the in-use fuel oil service tank; and
- (c) As close to the fuel oil combustion machinery as safely feasible taking into account the type of fuel oil, flow-rate, temperature, and pressure behind the selected sampling point.

2.2.5 The sampling arrangements within the machinery space are to be capable of safely providing samples when the machinery is running and are to be provided with isolating valves and cocks of the self-closing type.

Part 16, Chapter 1

Control Engineering Systems

■ Section 1

General requirements

1.2 Documentation required for design review

1.2.3 **Test schedules** (for both works testing and sea trials), which should include methods of testing (for example, simulation testing) and test facilities provided, see Pt 16, Ch 1, 7.4 Record of trials 7.4.1.

1.2.4 **System operational concept.** A description of the intended operation of the control, alarm, monitoring and safety systems for the main and auxiliary machinery, and other systems essential for the propulsion and safety of the ship. This description is to include a demonstration that the design provides an effective means of operation and control for all ship operating conditions.

1.5 Definitions

1.5.12 Sub-system: identifiable part of a system, which may perform a specific function or set of functions.

1.5.13 Programmable electronic equipment: physical component where software is installed.

1.5.14 Software module: a module is a standalone piece of code that provides specific and closely coupled functionality.

1.5.15 Simulation tests: system testing where simulation tools replace parts or all of the equipment, or where parts of the communication network and lines are replaced with simulation tools.

■ Section 2

Essential features for control, alarm, monitoring and safety systems

2.10 Programmable electronic systems - General requirements

2.10.1 The requirements of this sub-Section are to be complied with where control, alarm, monitoring or safety systems incorporate programmable electronic equipment. Systems for essential services and safety critical applications, systems incorporating shared data communication links and systems which are integrated are to comply with the additional requirements of Pt 16, Ch 1, 2.11 Data communication links, Pt 16, Ch 1, 2.13 Programmable electronic systems - Additional requirements for essential services and safety critical systems and Pt 16, Ch 1, 2.14 Programmable electronic systems – Additional requirements for integrated systems as applicable. For systems complying with ISO 17894, Ships and marine technology – Computer applications – General principles for the development and use of programmable electronic systems in marine applications, see Pt 16, Ch 1, 2.13 Programmable electronic systems – Additional requirements for essential services and safety critical systems.

2.10.13 Access to system configuration, programs and data is to be restricted by physical and/or logical means providing effective security against unauthorised alteration both for local and remote access.

2.10.20 Software lifecycle activities, e.g. design, development, supply and maintenance, are to be carried out in accordance with an acceptable quality management system which has lifecycle models suitable to the nature of the software project, considering its size, complexity, safety, risk and integrity. Project specific software quality plans are to be submitted. These are to demonstrate that the provisions of ISO/IEC 90003: Software engineering – Guidelines for the application of ISO 9001:2008 to computer software, or equivalent, are incorporated. The plans are to define responsibilities for the lifecycle activities, including verification, validation, software module testing and, integration with other components or systems and security policies to be applied.

2.13 Programmable electronic systems - Additional requirements for essential services and safety critical systems

2.13.1 The requirements of ~~Pt 16, Ch 1, 2.14 Programmable electronic systems – Additional requirements for integrated systems~~ 2.13.2 to Pt 16, Ch 1, 2.13 Programmable electronic systems - Additional requirements for essential services and safety critical systems are to be complied with where control, alarm, monitoring or safety systems for essential services, as defined by Pt 6, Ch 2, 1.6 Definitions, or safety critical systems, incorporate programmable electronic equipment.

- (a) Safety critical systems are those which provide functions intended to protect persons from physical hazards (e.g. fire, explosion, etc.), or to prevent mechanical damage which may result in the loss of an essential service (e.g. main engine low lubricating oil pressure shutdown).
- (b) Applications that are not essential services may also be considered to be safety critical (e.g. domestic boiler low water level shutdown).

■ Section 7 Trials

7.1 General

1.7.1.5 Before installation of programmable electronic systems programs, data and the physical medium used for installation on the vessel are to be scanned for viruses and malicious software. Results of the scan are to be documented, kept with the software registry and be available to the Surveyor on request.

Part 16, Chapter 2 Electrical Engineering

■ Section 1 General requirements

1.7 Design and construction

1.7.4 Permanently installed electrical and electronic equipment that are capable of generating electromagnetic interference, which can interfere with the proper functionality of essential services or services upon which they depend, are to be designed, constructed and installed in accordance with the guidelines and recommendations of one of the following standard(s), as appropriate to its location:

- (a) IEC 60533 - *Electrical and electronic installations in ships - Electromagnetic compatibility (EMC)*; or
- (b) IEC 60945 - *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*; or
- (c) LR Type Approval System – Test Specification Number 1;
- (d) Alternative national or international standard(s) acceptable to LR.

Existing paragraph 1.7.4 has been renumbered 1.7.5.

1.8 Quality of power supply

1.8.3 ~~Harmonics~~. Unless specified otherwise, the total harmonic distortion (THD) of the voltage waveform at any a.c. switchboard or section-board is not to exceed 8 per cent of the fundamental for all frequencies up to 50 times the supply frequency and no voltage at a frequency above 25 times the supply frequency is to exceed 1,5 per cent of the fundamental of the supply voltage. THD is the ratio of the rms value of the harmonic content to the rms value of the fundamental, expressed in per cent and may be calculated using the expression:

$$THD = \frac{\sqrt{\sum_{h=2}^{\infty} V_h^2}}{V_1} \times 100$$

where

V_h = rms amplitude of a harmonic voltage of order h

V_1 = rms amplitude of the fundamental voltage.

1.8.4 Where a higher value of THD is specified, all installed equipment and systems are to be designed for the higher specified limit. This relaxation on the limit is to be documented in the harmonic distortion calculation report.

Existing paragraph 1.8.4 has been renumbered 1.8.5.

1.12 Earthing of non-current carrying parts

1.12.1 Except where exempted by *Pt 16, Ch 2, 1.12 Earthing of non-current carrying parts 1.12.2*, all non-current carrying exposed metal parts of electrical equipment and cables are to be earthed, for personnel protection against electric shock. Bonding of non-current carrying exposed metal parts is to give a substantially equal potential and a sufficiently low earth fault loop impedance to ensure correct operation of protective devices.

1.18 Programmable electronic systems

1.18.1 Where programmable electronic systems are implemented and used to control the electrical installation, or to provide safety functions in accordance with the requirements of this Chapter (e.g. electric propulsion, circuit-breaker settings, switchgear and control gear controllers, etc.), the arrangements are to satisfy the applicable requirements of *Pt 16, Ch 1, 2.10 Programmable electronic systems - General requirements to Pt 16, Ch 1, 2.14 Programmable electronic systems - Additional requirements for integrated systems*.

■ Section 5 Supply and distribution

5.10 Harmonic distortion measurement

5.10.1 The requirements of *Pt 16, Ch 2, 5.10 Harmonic distortion measurement* apply to electrical distribution systems that include harmonic filters. This requirement applies both to high voltage and low voltage busbars. *See also Pt 16, Ch 2, 6.13 Harmonic filters*. Harmonic filters associated with frequency drives for individual applications (i.e. pump motors) are excluded from the following requirements.

5.10.2 Means are to be provided to continuously monitor the levels of harmonic distortion experienced on the main busbars and to operate an alarm in the engine control room, or equivalent attended position, in the event that the harmonic distortion exceeds the acceptable limits, *see also Pt 6, Ch 1, 4.2 Alarm system for machinery*.

5.10.3 Where the engine room is provided with automation systems to continuously monitor the levels of harmonic distortion experienced on the main busbars, this reading is to be logged electronically; otherwise it is to be measured annually and after any modification to the craft electrical distribution system or associated consumers and recorded in the engine log book for future inspection by the Surveyor.

5.11 Harmonic filtering

5.11.1 The requirements in this Section apply to systems provided with harmonic filters. They apply in particular to, but are not limited to, electrical propulsion systems and are in addition to the requirements for harmonic filters in *Pt 16, Ch 2, 6.13 Harmonic filters*.

5.11.2 Filters used to control harmonic distortion are to keep the distortion within acceptable limits at the main supply. *See also Pt 16, Ch 2, 1.8 Quality of power supply*.

5.11.3 The service life of the harmonic filter is to be declared, and details are to be included in the harmonic calculation report.

5.11.4 The temperature rating of the harmonic filter is to allow for the increased heating effect of the harmonic distortion.

5.11.5 The construction of cabinets for harmonic filters shall be in accordance with the standards for main switchboards, where applicable. *See also Pt 16, Ch 2, 7 Switchgear and controlgear assemblies*.

5.11.6 The modes of operation of the electrical distribution system for which harmonic distortion levels at the main switchboard busbars are maintained within the acceptable limits during normal operation are to be defined by the system integrator.

5.11.7 Harmonic distortion calculations are to include levels of harmonic distortion expected in normal operation and in the event of a failure of a harmonic filter or the failure of any combination of harmonic filters. *See also Pt 6, Ch 2, 21.2 Trials*.

■ Section 6 System design – Protection

6.13 Harmonic filters

6.13.1 Harmonic filters' final sub-circuits are to be protected individually and individually on each phase against overload and short-circuit. The activation of the protection arrangement in a single phase shall result in automatic disconnection of the complete filter.

6.13.2 A current imbalance detection system protection is to be installed; it is to be independent from the protection specified in *Pt 16, Ch 2, 6.13 Harmonic filters 6.13.1*.

6.13.3 An alarm is to be initiated in the event of protective device operation or current unbalance that could lead to failure of a harmonic filter.

6.13.4 Current imbalance circuits are to be 'fail safe'. The characteristics of the 'fail safe' operation are to be evaluated on the basis, not only of the system and its associated machinery, but also the complete installation, as well as the ship.

6.13.5 The reconnection of harmonic filters is to require manual intervention.

6.13.6 Individual harmonic filter capacitors are to be provided with a pressure relief valve or overpressure disconnecter to protect against damage from rupture where pressure build-up within hermetically sealed capacitors may occur.

■ Section 21 Testing and trials

21.2 Trials

(Part only shown)

21.2.4 It is to be demonstrated that the Rules have been complied with in respect of:

- (f) harmonic distortion of the voltage waveform, ~~where declared~~; Where harmonic filters are installed the calculation results provided by the system integrator are to be verified by the Surveyor. Simulation of harmonic filter failure during trials is not to exceed the THD limit. See Pt 6, Ch 2, 5.11 Harmonic filtering;
- (g) satisfactory parallel operation, and kW and KVA load sharing of all generators capable of being operated in parallel at all loads up to normal working load;
- (h) alarm sound pressure levels; and
- (i) all essential and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously, for a sufficient length of time to demonstrate that they are satisfactory.

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